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DISEASE DETECTION SURVEY
Air Pollution

Apache National Forest
Arizona

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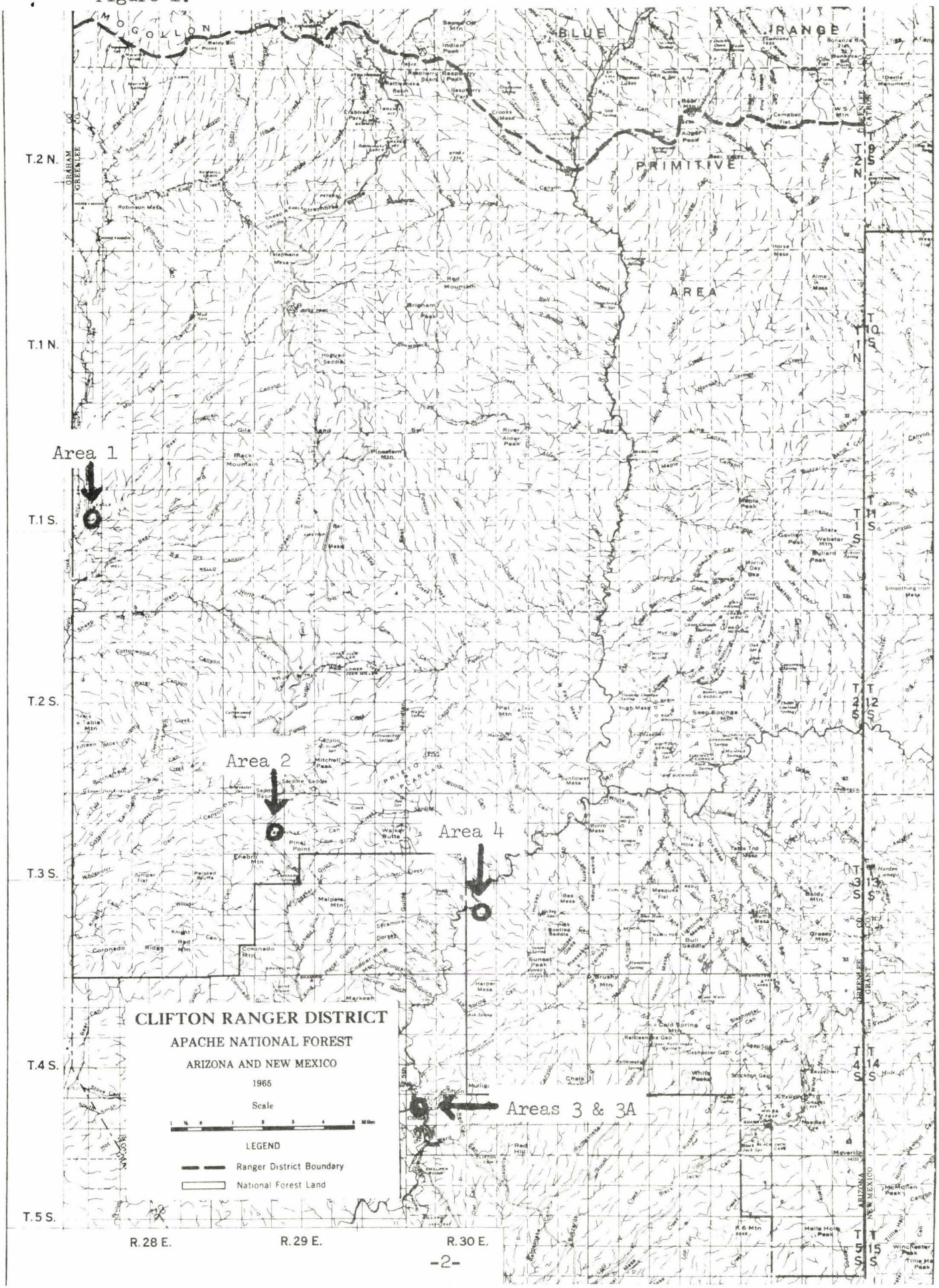
In September 1971, Robert Loomis, plant pathologist in the Forest Service Insect and Disease Branch, and James Montoya, District Range Staff, Clifton Ranger District, examined forest trees and associated plants on selected areas of the Clifton Ranger District, Apache National Forest. The purpose of the survey was to determine if acute injury had occurred to forest vegetation from SO_2 emitted by the Phelps Dodge copper smelter, located at Morenci, Arizona. No symptoms of acute SO_2 injury were found on vegetation in the Apache National Forest; however, symptoms of acute SO_2 injury were noted on plants approximately 4 miles from the smelter. Chlorotic foliage, a symptom of several plant disorders including chronic SO_2 injury, was noted in several locations on the Forest. The significance of this symptom has yet to be determined because chlorotic foliage can also be found in areas far removed from sources of SO_2.

Method.--A detection system, consisting of four vegetative observation areas and sulfation plate stations (Figure 1), was initiated in May 1971. The sulfation plate stations and observation areas were established together in species type and location most susceptible to SO_2 injury. By locating the sulfation plates and observation areas together, we may be able to determine if there is a relationship between sulfation rate and the presence or absence of plant injury. By finding areas most susceptible to SO_2 injury, the detection system is made more sensitive to possible SO_2 injury.

Considerations for establishing observation areas include:

1. Presence of a variety of trees and associated plants growing in the area. One phase in evaluating possible SO_2 injury to plants

Figure 1.


MOGOLLON
BLUE
RANGE
PRIMITIVE
AREA
T.2 N.
T.1 N.
T.1 S.
T.2 S.
T.3 S.
T.4 S.
T.5 S.
R.28 E.
R.29 E.
R.30 E.
GRAHAM
GREENLEE
Area 1
Area 2
Area 4
Areas 3 & 3A
CLIFTON RANGER DISTRICT
APACHE NATIONAL FOREST
ARIZONA AND NEW MEXICO
1965
Scale
LEGEND
Ranger District Boundary
National Forest Land

is to determine if similar injury had occurred to a variety of plant species.1/

2. The observation areas should have adequate soil moisture. Plants growing in areas with adequate soil moisture and high humidity are more susceptible to SO_2 injury than plants growing under arid conditions.1/

The foliage of trees and associated plants was examined for the interveinal bleaching, interveinal necrosis, and tip burn typical of acute SO_2 injury. In addition, leaf and needle abnormalities from other causes were noted for future reference.

Results.--The following forest trees and associated plants were examined for symptoms of SO_2 injury:

Forest Trees

Ponderosa pine (Pinus ponderosa)
Douglas-fir (Pseudotsuga menziesii)
Aspen (Populus tremuloides)
Wild cherry (Prunus spp.)
Gambel oak (Quercus gambelii)
Cottonwood (Populus spp.)
Box elder (Acer negundo var. interius)
Willow (Salix spp.)
Arizona walnut (Juglans major)
Mesquite (Prosopis spp.)
Tamarisk (Tamarix gallica)
Arizona cypress (Cupressus arizonica)
Arizona sycamore (Platanus wrightii)

Forest Plants and Shrubs

Wild tobacco (Nicotiana glaucia)
Cockelbur (Xanthium spp.)
Grape (Vitis spp.)
Sunflower (Helianthus spp.)
Wright silktassel (Garrya wrightii)
Jimmyweed (Aplopappus heterophyllus)
Brickellbush (Brickellia spp.)

Tree and plant condition was noted as follows:

1. Chlorosis of sycamore and sunflower foliage was noted in some drainages along the road to Area 1. Foliage of all tree and plant species in Area 1 appeared normal.

1/ Air Pollution Control Assoc. 1971. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Jacobson, J. S., and A. C. Hill, Editors. Pittsburgh, Pa.

2. Chlorosis and necrosis of sycamore foliage (Figure 2) was noted along the San Francisco River between Clifton and Area 4. These leaf markings could be symptoms of SO_2 injury; however, other foliage diseases and evidence of insect feeding were also noted on the sycamore trees. Further examination and study is necessary in order to determine if SO_2 is contributing to this problem. Grape foliage had a bleached appearance in this same general area; however, this injury is thought to be caused by insect feeding.

3. Typical symptoms of SO_2 injury were noted on the foliage of brickellbush located between Clifton and Area 2, approximately 4 miles from the smelter (Figure 2). The interveinal bleaching is considered to be a classical symptom of SO_2 injury.

The foliage of some wild cherry trees in Area 2 had necrotic spots (Figure 2). This symptom was not found consistently in the area. The foliage of other trees and plants appeared normal. Ponderosa pine needle retention also appeared normal.

Sulfation plate data for the period May-November 1971 are as follows:

Area 1 - Clifton Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
May 1971	26	** <Detectable minimum
Jun.	38	<Detectable minimum
Jul.	36	<Detectable minimum
Aug.	22	--
Sep.	32	1.8
Oct.	44	<Detectable minimum
Nov.	27	<Detectable minimum

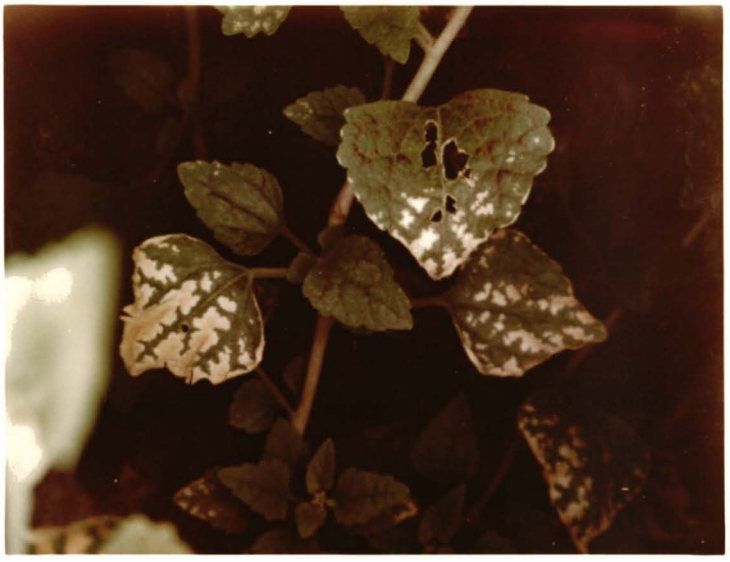
* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
May 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Figure 2.

Chlorosis and necrosis of sycamore foliage, San Francisco River.

Necrotic spots on wild cherry foliage, Area 2.



Typical symptoms of SO_2 injury to brickellbush foliage.

Area 2 - Clifton Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
May 1971	29	3.8
Jun.	35	6.4
Jul.	29	1.6
Aug.	29	7.6
Sep.	32	** <Detectable minimum
Oct.	44	4.7
Nov.	26	2.2

Area 3 - Clifton Ranger District

May 1971	30	8.5
Jun.	36	14.3
Jul.	25	<Detectable minimum
Aug.	40	3.8
Sep.	26	<Detectable minimum
Oct.	46	9.4
Nov.	24	3.4

Area 3A - Clifton Ranger District

Sep. 1971	26	<Detectable minimum
Oct.	46	6.1
Nov.	24	<Detectable minimum

Area 4 - Clifton Ranger District

May 1971	28	<Detectable minimum
Jun.	33	7.2
Jul.	23	<Detectable minimum
Aug.	42	2.6
Sep.-Nov.	Sulfation plate inaccessible due to road washout	

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** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
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Discussion.--Diagnosis of air pollution injury to vegetation is complicated by environmental, insect, and other disease factors. These factors can cause leaf and plant symptoms which appear similar to air pollution injury. In addition, the occurrence or severity of air pollution-caused plant injury is determined not only by the pollutant concentrations and duration of exposure, but by many environmental factors which can affect individual plant sensitivity. These factors include light, moisture, temperature, and nutrient relations.2/

To date, the only places we have found symptoms of acute SO_2 injury to Southwestern forest vegetation have been within 4 miles of the source emitting SO_2. We do not presently have enough data to know, for Southwestern conditions, if acute or chronic injury is occurring to sensitive forest vegetation at distances greater than 4 miles from the source. Surveys, such as the one reported here, will help to establish where injury is occurring, and what the impact of SO_2 might be on Southwestern forest vegetation.

Sulfation plates are being used to determine if SO_2 and other sulfur compounds are reaching the vegetative observation areas.3/ The sulfation plates are exposed for approximately 30 days, during which time sulfur compounds react with the lead dioxide in the plate. The product of these reactants is then measured and expressed as micrograms $SO_3/cm^2/day$.4/ This is commonly called the sulfation rate. To date, no relationship has been noted between sulfation rate and the presence of plant injury. Comparisons have not been possible because most of the acute plant injury we have found has not been in the vicinity of our sulfation plate stations. Sulfation plates provide an economical way of determining the general dispersion of total sulfur compounds, and, therefore, may prove useful in finding locations more susceptible to SO_2 injury. Eventually, it may be possible to develop an area plant hazard rating system based on average sulfation rates and relative susceptibility of native forest species.

In order to get some idea of sulfation plate reliability, duplicate plates were exposed in six locations in New Mexico and Arizona. The

2/ Treshow, M. 1970. Environment and Plant Response. McGraw-Hill Book Co., N.Y. 422 p.
3/ Tucson Advisory Committee on Air Pollution. 1971. Air Pollution in Tucson: A Report to the Major and Council of the City of Tucson. Edited by R. Caldwell. 141 p.
4/ Huey, N. A. 1968. The Lead Dioxide Estimation of Sulfur Dioxide Pollution. J. Air Poll. Control Assoc. 18: 9.

sulfation rates of several individual plate-pairs varied considerably; however, when all plate-pairs are considered, there is a highly significant correlation between the sulfation rates on each of the plate-pairs (R = 0.859 with 26 degrees of freedom). There is no significant difference between the average of the means of each set of plate-pairs (T = 1.030 with 26 degrees of freedom).

A map showing the areas examined in our 1971 air pollution detection survey is attached.

Recommendations.--

1. Conduct a detection survey on the Clifton Ranger District in the late summer of 1972 to determine if symptoms of acute or chronic SO_2 injury can be found on forest vegetation.

2. Continue the monthly changing of sulfation plates, at least until November 1972.

AIR POLLUTION DETECTION SURVEY - 1971
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